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(54) **Method for molding polypropylene resin.**

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(73) Proprietor: **SUMITOMO CHEMICAL COMPANY, LIMITED**
Kitahama 4-chome 5-33
Chuo-ku
Osaka 541 (JP)

(72) Inventor: **Hara, Takahisa**
3-4-1-202, Higashitada
Kawanishi-shi,
Hyogo-ken (JP)
Inventor: **Matsumoto, Masahito**
2-1-133, Kuwata-cho
Ibaraki-shi,
Osaka-fu (JP)
Inventor: **Usui, Nobuhiro**
1-9-1-501, Tamagawa
Takatsuki-shi,
Osaka-fu (JP)
Inventor: **Matubara, Shigeyoshi**
1-7-3, Zuiko,
Higashiyodogawa-ku
Osaka-shi,
Osaka-fu (JP)

(74) Representative: **VOSSIUS & PARTNER**
Postfach 86 07 67
D-81634 München (DE)

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Description

The present invention relates to a method for molding a polypropylene resin. More particularly, the present invention relates to a method for molding a foamed article of a polypropylene resin having good appearance.

For the production of a foamed article of a thermoplastic resin, injection molding methods have been proposed (sea Japanese Patent Publication No. 22213/1964 and Japanese Patent Kokai Publication No. 24913/1985).

However, the above conventional processes have some drawbacks as follows:

In the method disclosed in Japanese Patent Publication No. 22213/1964, the foaming condition in the step for supplying a resin melt in a mold cavity is insufficiently controlled. Then, in some cases, a part of the resin is already foamed in the resin supplying step so that it is difficult to produce stably a molded article having no flash or silver mark on an article surface. In the method disclosed in Japanese Patent Kokai Publication No. 24913/1985, the apparatus for injecting a fluid or gas into the resin melt for foaming and the position of foaming of an article is largely limited by the position of the inlet for the liquid or gas.

According to GB-A-1201040, an injection-molded vehicle body panel is provided having ribs and/or bosses integrally molded therewith and having a foamed core of a thermoplastic material integrally molded with solid surface layers made by injecting a mass of thermoplastic material containing a blowing agent at a temperature above that at which the blowing agent is activated into a mold, the mold being filled so said foaming is substantially prevented and moving the mold surfaces away from one another to a predetermined extent to allow the core of the thermoplastic to foam.

An object of the present invention is to provide a method for producing a foamed article of a polypropylene resin having good appearance.

According to the present invention, there is provided a method for producing a foamed article of a polypropylene resin, which comprises steps of:

providing a pair of male and female molds which are slidably moveable at an engaged part and in which a cavity clearance can be freely set,

supplying a melt of a polypropylene resin containing a chemical blowing agent in the molds

increasing said cavity clearance (t) to form a foamed core layer

cooling the foamed article in said molds

the method being characterized by the steps of

starting supply of a melt of polypropylene resin containing a blowing agent through a resin melt conduit which is provided in one of said male or female molds when the cavity clearance is 1.0 mm or less,

moving at least one of said male and female molds to increase said cavity clearance (t) during said supply of said polypropylene resin melt (8) so that the pressure on said resin melt in said mold cavity is adjusted in a range between 5 kg/cm^2 and 100 kg/cm^2,

forming a skin layer at parts of the resin melt which are contacted to the inner surfaces of the molds by applying a pressure of from 5 kg/cm^2 to 100 kg/cm^2 on said resin melt (8) as soon as said resin supply is finished,

further increasing said cavity clearance (t) so that the inner part of the resin melt is blown to form the foamed core layer.

Fig. 1 illustrates the change of the cavity clearance (t) in the molding steps according to the present invention,

Figs. 2 and 3 are cross sections of a molding apparatus used in the molding method of the present invention,

Fig. 4 is a perspective view of a disc produced by the method of the present invention, and

Fig. 5 is a box-shape article produced by the method of the present invention.

Now, the present invention will be explained by making reference to the accompanying drawings.

Fig. 2 shows a cross section of a mold to be used in the method of the present invention, which comprises a pair of platens 1,2, a female mold 3 attached to the upper platen 1 and a male mold 4 attached to the lower static platen 2. The platen 1 is connected to a hydraulic driving unit (not shown) and the female mold 3 is vertically moved. The male and female molds are slidably engaged at a part 5, and a distance between the male and female molds at the engaging part 5 is so small that the resin melt is not squeezed out through this part. The male and female molds define a cavity 6, and a cavity clearance (t) can be freely set by vertically moving the female mold.

The male mold 4 has a resin melt conduit 7, one end 7' of which is connected to a resin supplier (not shown) which plasticizes the resin and supplies a resin melt 8 into the cavity 6.

Fig. 3 shows a cross section of the mold of Fig. 2 just after the molding is finished and before the molds are opened. The numeral 8' stands for a foamed article.

Fig. 1 illustrates molding steps of one embodiment of the method of the present invention, in which, a vertical axis represents a cavity clearance (t) and a horizontal axis represents a time during the molding.

One embodiment of the method of the present invention will be explained by making reference to Fig. 1.

First, from a point A at which the male and female molds are open, the driving unit is actuated to lower the female mold to a point B at which the cavity clearance (t) is 1.0 mm or less. Then, a polypropylene resin melt 8 containing a chemical blowing agent is supplied through the resin melt conduit 7 into the cavity 6 (first step).

After the resin melt supply is started, the female mold is lifted up to increase the cavity clearance (t) so that the pressure on the resin melt is maintained in the range between 5 to 100 kg/cm^2 during the supply of the resin melt, whereby, the resin melt is supplied all over the cavity surface (second step, between the points C and D in Fig. 1).

The reason why the first and second steps are carried out as above is that the foaming of the resin melt is suppressed in these steps.

From the point D at which the resin melt supply is finished, a pressure of 5 to 100 kg/cm^2 is applied onto the resin melt in the cavity and kept for a certain time period to form a skin layer (third step, between the points D and E in Fig. 1).

The time period for keeping the pressure between the points D and E is selected so that parts of the resin melt which are contacted to inner surfaces of the molds are cooled and solidified while the interior part of the resin melt is not solidified and is in a foamable state. Such time period is selected according to the thickness of the foamed article and/or the expansion ratio.

After the formation of the skin layer, the female mold is lifted up to increase the cavity clearance (between the points E and F) so that the inner part of the resin melt is blown to form a foamed core layer. Thereafter, the molded article is cooled to obtain a foamed article (fourth step, between the points E and G in Fig. 1).

In his cooling step, the cavity clearance may be kept constant or may be decreased to pressurize the article after the foamed core layer is cooled and solidified to some extent. In particular, by pressurizing the foamed article after the core layer is cooled and solidified to some extent, warp of the article having a shape which tends to be warped is effectively prevented.

Finally, the female mold 3 is further lifted up till the cavity clearance reaches the point H in Fig. 1 and the molded article is removed from the molds.

In the method of the present invention, since the resin melt 8 is supplied in the mold cavity in the first and second steps with suppressing foaming, the skin layer is formed in the third step and only the core layer is foamed in the fourth step, the skin layer includes no foam and is smooth. Further, since resin melt flows in the mold cavity while the foaming is suppressed and then molded to form the skin layer, it is possible to produce the foamed article of polypropylene which has the surface with good gloss without having flash or a silver mark and further does not suffer from warp or a sink mark.

In the above described embodiment, the upper platen is moved while the lower platen is fixed. In another embodiment, the upper platen is fixed and the lower platen is moved. Further, in the above described embodiment, the upper mold is the female mold and the lower mold is the male mold. But, the upper mold can be the male mold and the lower mold can be the female mold.

The polypropylene resin includes not only a homopolymer of propylene but also a copolymer of propylene with at least one other comonomer such as ethylene Further, the polypropylene resin may contain other resin such as polyethylene or a thermoplastic elastomer, or a filler such as calcium carbonate or talc. However, the content of the polypropylene resin should be at least 50 % by weight in a composition.

As the chemical blowing agent to be used in the method of the present invention, any of chemical blowing agents which are conventionally used to blow the polypropylene resin may be used. Examples of the chemical blowing agent are inorganic blowing agents (e.g. sodium bicarbonate) and organic blowing agents (e.g. azodicarbonamide).

In the method of the present invention, it is possible to provide a skin material in the mold cavity and then to supply the resin melt and blow the resin melt according to the method of the present invention to obtain a foamed article of the polypropylene resin having the adhered skin material. As the skin material, any material may be used according to the object of the use of the skin material. For example, the skin material may be an embossed polyvinyl chloride leather lined with a fabric, or an embossed olefinic elastomer.

The present invention will be illustrated by following Examples.

Example 1

As a molding resin, polypropylene (Sumitomo Noblen (trademark) AX 568, MFR 65 g/10 min. manufactured by Sumitomo Chemical Co., Ltd.) containing 3 % by weight of an azodicarbonamide blowing agent (Cellmike MB 3062 manufactured by Sankyo Chemical Co., Ltd.) was used.

A mold had a cavity for producing a disc shown in Fig. 4 having a diameter of 300 mm, and the disc was molded in the following steps.

First step

The male and female molds were closed to a cavity clearance of 0.5 mm, and the supply of the resin melt was started (Fig. 1, the point C).

Second step

The cavity clearance was increased to 4.0 mm so as to adjust the pressure on the rein melt to 30 kg/cm^2 during the supply of the resin melt (Fig. 1, between the points C and D).

Third step

After the supply of the resin melt, the pressure of 5 kg/cm^2 was applied onto the resin melt and kept at the same pressure for 20 seconds to form a skin layer (Fig. 1, between the points D and E).

Fourth step

After the formation of the skin layer, the cavity clearance was increased to 5.0 mm (Fig. 1, between the points E and F) and kept at that distance for 40 seconds to form a foamed core layer, the molds were cooled (Fig. 1, between the points F and G) to obtain a disc having a thickness of 5 mm with a blow ratio of 1.25.

The properties of the produced disc are shown in the Table. As seen from the Table, the produce disc had good appearance with no warp, sink mark, flash or silver mark.

Comparative Example 1

In the same manner as in Example 1 except that, in the first step, the supply of the resin melt was started when the cavity clearance was 3.0 mm, a disc was molded. The surface of the disc had flashes and silver marks.

Comparative Example 2

In the same manner as in Example 1 except that, in the second step, the pressure on the resin melt was 3 kg/cm^2, a disc was molded. The disc had flashes and silver marks.

Comparative Example 3

In the same manner as in Example 1 except that, in the third step, after the supply of the resin, the pressure was applied on the resin melt for 12 seconds (Fig. 1, between the points D and E), a disc was molded. The surface of the disc had many depressions due to sink marks.

Example 2

As a polypropylene resin, the same Sumitomo Noblen AX 568 as used in Example 1 was used, and 6 % by weight of Daiblow PE-M 20 (AL) NK (manufactured by Dainichi Seika) was added to the resin. The mold had a cavity for molding a box-shape article of Fig. 5 having sizes of 400 mm x 400 mm x 20 mm, a height of 20 mm and a wall thickness of 2 mm. the article was molded in the following steps.

First step

The male and female molds were closed to a cavity clearance of 0.5 mm, and the supply of the resin melt was started (Fig. 1, the point C).

Second step

The cavity clearance was increased to 1.7 mm so as to adjust the pressure on the rein melt at 50 kg/cm^2 during the supply of the resin melt (Fig. 1, between the points C and D).

Third step

After the supply of the resin melt, the pressure of 20 kg/cm^2 was applied onto the resin melt and kept at the same pressure for 2 seconds to form a skin layer (Fig. 1, between the points D and E).

Fourth step

After the formation of the skin layer, the cavity clearance was increased to 2.0 mm (Fig. 1, between the points E and F) and kept at that distance for 30 seconds to form a foamed core layer, the molds were cooled (Fig. 1, between the points F and G) to obtain a box-shape article having a wall thickness of 2 mm with a blow ratio of 1.20.

The properties of the produced box-shape article are shown in the Table. As seen form the Table, the produce article had good appearance with no warp, sink mark, flash or silver mark.

Comparative Example 4

In the same manner as in Example 2 except that, in the second step, the pressure applied on the resin melt during the supply of the resin melt was 120 kg/cm^2, a box-shape article was molded. The article was warped.

Example 3

A disc having a skin material on its surface was molded. As the skin material, a polyvinyl chloride leather lined with a woven fabric having a thickness of 0.6 mm was used. The surface of the fabric which contacted to the leather was partly embedded in the leather resin to adhere the fabric to the leather. As a polypropylene resin, the same Sumitomo Noblen AX 568 as used in Example 1 was used, and 6 % by weight of Daiblow PE-M (AL) N (manufactured by Dainichi Seika) was added to the resin.

The disc was molded in the following steps.

First step

The skin material was placed on the male mold with the leather side facing upwards.

The male and female molds were closed to a cavity clearance of 0.9 mm which was a difference between the distance (1.5 mm) between the inner surfaces of the molds and the thickness of the skin material (0.6 mm) and the supply of the resin melt was started (Fig. 1, the point C).

Second step

The cavity clearance was increased to 4.0 mm so as to adjust the pressure on the rein melt to 50 kg/cm^2 during the supply of the resin melt (Fig. 1, between the points C and D).

Third step

After the supply of the resin malt, the pressure of 5 kg/cm^2 was applied onto the resin melt and kept at the same pressure for 20 seconds to form a skin layer (Fig. 1, between the points D and E).

Fourth step

After the formation of the skin layer, the actual cavity clearance was increased to 5.0 mm (Fig. 1, between the points E and F) and kept at that distance for 45 seconds to form a foamed core layer, the molds were cooled to obtain a disc having a thickness of 5.6 mm with a blow ratio of 1.25 and the adhered skin material on one surface (Fig. 1, between the points F and G).

The properties of the produced disc are shown in the Table. As seen from the Table, the produce disc had good appearance with no warp, sink mark, flash or silver mark.

Table

Example No.	Molding conditions					Molded article		
	Cavity clearance at start of resin supply (mm)	Pressure during supply of resin melt (kg/cm^2)	After resin supply		After formation of skin layer		Thickness (mm)	Blow ratio (times)	Appearance
			Pressure on resin melt (kg/cm^2)	Time (sec.)	Cavity clearance (mm)	Time (sec.)			
1	0.5	30	5	20	5.0	40	5.0	1.25	Good; no warp sink mark, flash or silver mark
C. 1	3.0	30	5	20	5.0	40	5.0	1.25	Flash and silver marks
C. 2	0.5	3	5	20	5.0	40	5.0	1.25	↓
C. 3	0.5	30	5	12	5.0	40	5.0	1.25	Small depressions due to sink marks
2	0.5	50	20	2	2.0	30	2.0	1.20	Good; no warp sink mark, flash or silver mark
C. 4	0.5	120	20	2	2.0	30	2.0	1.20	Warped
3	0.9	30	5	20	5.0	45	5.6	1.25	No warp or sink mark; No flash or silver marks on a surface without a skin material,

Claims

1. A method for producing a foamed article of a polypropylene resin, which comprises steps of:
providing a pair of male and female molds which are slidably moveable at an engaged part and in which a cavity clearance can be freely set,

supplying a melt of a polypropylene resin containing a chemical blowing agent in the molds
increasing said cavity clearance (t) to form a foamed core layer
cooling the foamed article in said molds
the method being characterized by the steps of
starting supply of a melt of polypropylene resin containing a blowing agent through a resin melt conduit which is provided in one of said male or female molds when the cavity clearance is 1.0 mm or less,
moving at least one of said male and female molds to increase said cavity clearance (t) during said supply of said polypropylene resin melt (8) so that the pressure on said resin melt in said mold cavity is adjusted in a range between 5 kg/cm^2 and 100 kg/cm^2,
forming a skin layer at parts of the resin melt which are contacted to the inner surfaces of the mold: by applying a pressure of from 5 kg/cm^2 to 100 kg/cm^2 on said resin melt (8) as soon as said resin supply is finished,
further increasing said cavity clearance (t) so that the inner part of the resin melt is blown to form the foamed core layer.

2. The method according to claim 1, wherein the resin melt supply is started when said cavity clearance (t) is 0.5 mm or less.

3. The method according to claim 1, wherein said propylene resin is a homopolymer of propylene.

4. The method according to claim 1, wherein said propylene resin is a copolymer of propylene with at least one other monomer.

Patentansprüche

1. Verfahren zur Herstellung eines geschäumten Artikels aus einem Polypropylenharz mit den folgenden Schritten:
Bereitstellen eines Formenpaars aus einer Patrize und einer Matrize, die verschiebbar an einem Eingriffsteil beweglich sind und bei denen sich ein Hohlraumabstand frei einstellen laßt,
Zuführen einer Schmelze aus einem Polypropylenharz, das ein chemisches Treibmittel enthält, in die Formen,
Erhöhen des Kohlraumabstands (t), um eine geschäumte Kernschicht auszubilden, und
Abkühlen des geschäumten Artikels in den Formen,
wobei das Verfahren durch die folgenden Schritte gekennzeichnet ist:
Beginnen der Zufuhr einer Schmelze aus Polypropylenharz, das ein Treibmittel enthält, durch eine Harzschmelzleitung, die in der Patrize oder Matrize vorgesehen ist, wenn der Hohlraumabstand 1,0 mm oder weniger beträgt,
Bewegen mindestens der Patrize oder Matrize, um den Hohlraumabstand (t) während der Zufuhr der Polypropylenharzschmelze (8) so zu erhöhen, daß der Druck auf die Harzschmelze in dem Formenhohlraum in einem Bereich zwischen 5 kg/cm^2 und 100 kg/cm^2 eingestellt wird,
Ausbilden einer Außenschicht an Teilen der Harzschmelze, die mit den Innenflächen der Formen in Berührung stehen, durch Ausüben eines Drucks von 5 kg/cm^2 bis 100 kg/cm^2 auf die Harzschmelze (8), sobald die Harzzufuhr beendet ist, und
weiteres Erhöhen des Hohlraumabstands (t), so daß das Innenteil der Harzschmelze aufgetrieben wird, um die geschäumte Kernschicht auszubilden.

2. Verfahren nach Anspruch 1, wobei die Zufuhr der Harzschmelze begonnen wird, wenn der Hohlraumabstand (t) 0,5 mm oder weniger beträgt.

3. Verfahren nach Anspruch 1, wobei das Polypropylenharz ein Homopolymer von Propylen ist.

4. Verfahren nach Anspruch 1, wobei das Polypropylenharz ein Copolymer von Propylen mit mindestens einem anderen Monomer ist.

Revendications

1. Procédé de production d'un article de mousse d'une résine de polypropylène, comprenant les étapes suivantes :

la disposition de deux moules mâle et femelle qui peuvent coulisser dans une partie de coopération et dans lesquels un espace de cavité peut être réglé librement,

la transmission d'une résine de polypropylène fondue contenant un agent chimique porogène dans les moules,

l'augmentation de l'espace (t) de la cavité pour la formation d'une couche de mousse d'âme, et

le refroidissement de l'article sous forme de mousse à l'intérieur des moules,

le procédé étant caractérisé par les étapes suivantes :

le début de la transmission d'une résine de polypropylène fondue contenant un agent porogène par un conduit de résine fondue placé dans l'un des moules mâle et femelle lorsque l'espace formé dans la cavité est inférieur ou égal à 1,0 mm,

le déplacement de l'un au moins des moules mâle et femelle afin que l'espace (t) de la cavité augmente pendant la transmission de la résine de polypropylène fondue (8), alors que la pression appliquée à la résine fondue dans la cavité du moule est ajustée à une valeur comprise entre 5 et 100 bar (5 à 100 kg/cm^2),

la formation d'une couche de peau dans des parties de la résine fondue qui sont au contact des surfaces internes des moules par application d'une pression comprise entre 5 et 100 bar (5 et 100 kg/cm^2) à la résine fondue (8) dès que la transmission de résine est terminée, puis

l'augmentation de l'espace (t) de la cavité afin que la partie interne de résine fondue se dilate en formant la couche d'âme de mousse.

2. Procédé selon la revendication 1, dans lequel la transmission de la résine fondue commence lorsque l'espace (t) de la cavité est inférieur ou égal à 0,5 mm.

3. Procédé selon la revendication 1, dans lequel la résine de polypropylène est un homopolymère de propylène.

4. Procédé selon la revendication 1, dans lequel la résine de polypropylène est un copolymère de propylène avec au moins un autre monomère.

Fig. 1

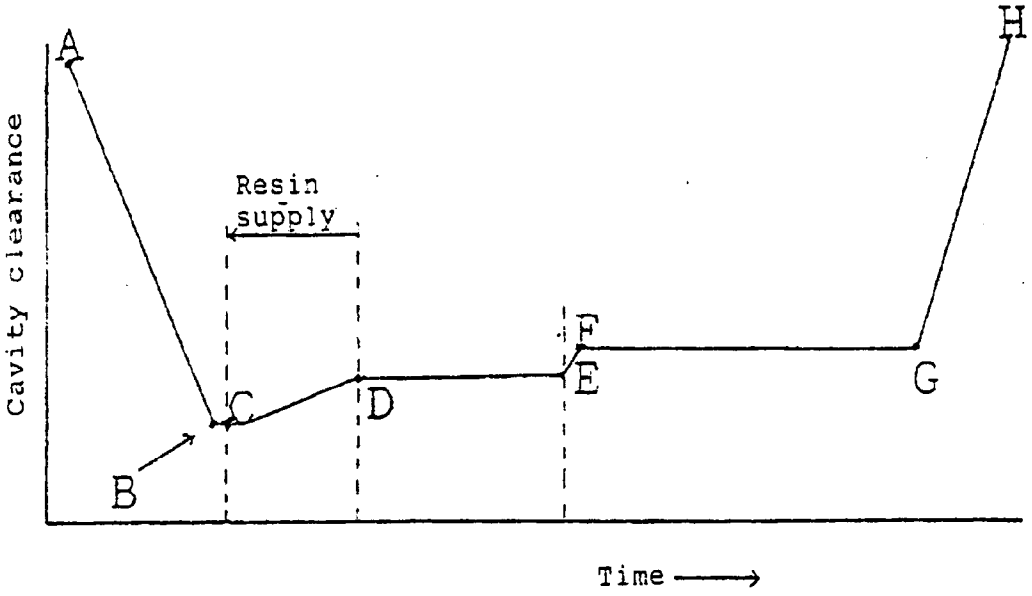

Fig. 2

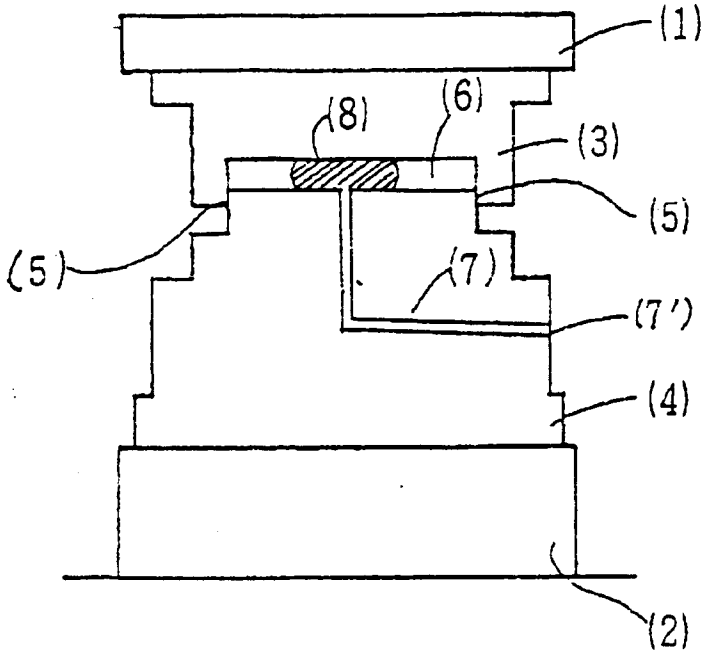

Fig. 3

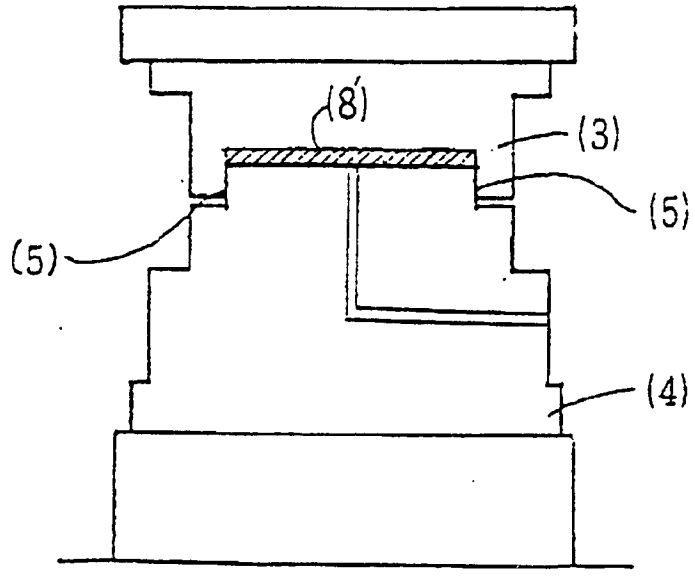

Fig. 4

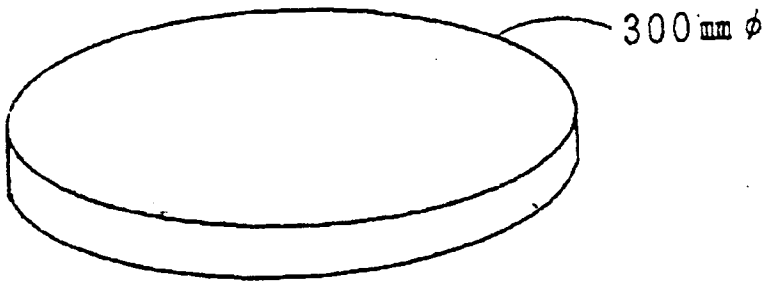

Fig. 5